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The influence of costs and benefits' analysis on service strategy formulation: Learnings from the shipping industry

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Abstract: Although servitization as a transformation process is being recognized by an increasing number of firms as a source of competitive advantage, the role of economic evaluations in service strategy formulation has so far attracted limited attention – and predominantly from the manufacturer perspective. This paper assesses how the analysis of costs and benefits of Product-Service Systems (PSS) as servitized offerings influences the formulation of service strategies in the shipping industry. The study examines both the manufacturer and customer perspectives using two case studies from the shipping sector. Life Cycle Costing (LCC) was used as a tool to assess the associated costs and benefits of two proposed PSS. Based on the results of the LCC, the drivers and barriers of the actual transformation processes were explored through workshops and interviews served to map the perspectives of both manufacturers and customers. For both case studies the LCC revealed that, while the PSS resulted in a decrease in life cycle costs and a possible revenue opportunity, there was also a lack of fundamental demand for PSS that could complicate the formulation of service strategies. Towards formulating service strategies, the analysis of costs and benefits highlighted the importance of the abilities of both the customer and the manufacturer to deliver and implement a PSS. Moreover, the customer perspective highlighted the importance of internal functions and capabilities that allowed the customer to implement and benefit from service strategies.

ABOUT THE AUTHOR

Aris Pagoropoulos is working towards his PhD in the department of Mechanical Engineering in the Technical University of Denmark. He has co-authored a series of articles in the areas of Product-Service Systems, life cycle assessment, artificial intelligence, digitization, production line scheduling and manufacturing complexity. He is currently involved in research together with the Danish shipping industry.

PUBLIC INTEREST STATEMENT

Although servitization as a transformation process is being recognized by an increasing number of firms as a source of competitive advantage, the role of economic evaluations in service strategy formulation has so far attracted limited. This paper assesses how the analysis of costs and benefits of Product-Service Systems (PSS) as servitized offerings-influences the formulation of service strategies in the shipping industry. Life Cycle Costing (LCC) was used as a tool to assess the associated costs and benefits of two proposed PSS from the shipping industry. Results showed that the PSS resulted in a decrease in life cycle costs, there was also a lack of fundamental demand for PSS that could complicate the formulation of service strategies. Towards formulating service strategies, the analysis of costs and benefits highlighted the importance of the abilities of both the customer and the manufacturer to deliver and implement PSS.

Subjects: Life-Long Design; Cost Accounting; Production, Operations & Information Management

Keywords: product-service systems; maritime industry; life cycle costing; servitization; service strategy

1. Introduction

In recent years, servitization has attracted considerable attention from both academia and industry. Through innovation of capabilities and processes, companies eventually shift from selling products to selling Product-Service Systems (PSS) (Baines, Lightfoot, Benedettini, & Kay, 2009). By definition, PSS create customer utility and generate value (Tukker, 2015), in an effort to introduce of new profit centres (Vandermerwe, 1990), plus higher revenues and margins (Gebauer, Fleisch, & Friedli, 2005; Martinez, Bastl, Kingston, & Evans, 2010; Neely, 2009). Exploratory studies shows that manufacturers are increasingly offering PSS (Crozet & Milet, 2014; Neely, Benedetinni, & Visnjic, 2011), while the UK Government's report on the future of manufacturing identifies servitization as a core element in its vision for the future of manufacturing (Foresight, 2013). Service strategies are important for PSS, as they help guide the servitization process, so that it can result in value in use to the customer (Baines et al., 2007; Roy & Cheruvu, 2009) and improved corporate competitiveness for the manufacturer (Belvedere, Grando, & Bielli, 2013; Miller, Hope, Eisenstat, Foote, & Galbraith, 2002; Shepherd & Ahmed, 2000).

Economic metrics such as costs and revenues are fundamentally connected to value. Settanni, Newnes, Thenent, Parry, and Goh (2014) argue that the cost of providing an advanced service through a PSS is the cost of delivering value "in use" through an outcome. But while the economic benefits and implications of PSS have been explored—most notably in (Lindahl, Sundin, & Sakao, 2014; Sawhney, 2004)—it is not clear how the analysis of costs and benefits influences the formulation of service strategies.

The focus of this paper is to evaluate the role of costs and benefits for PSS in the formulation of service strategies for manufacturers and customers alike. The study placed a particular focus on the customer perspective, as we believe that this perspective has remained under-researched in literature. Owing to the socially engaged character of PSS, we followed a case study approach (Eisenhardt & Graebner, 2007), by performing a four-way comparison between two case studies and two perspectives (i.e. manufacturer and customer). Performance agreements are a priori defined as the PSS under study, and can be seen as a form of advanced service that provides customers with a capability, as opposed to simple, more conventional services such as maintenance or customer support services (Baines & Shi, 2015; Saccani, Visintin, & Rapaccini, 2014). Performance agreements are investigated within two case studies from the shipping industry, and in particular two systems that play an important role for fuel efficiency on board vessels: coating systems and steam producers.

Our results suggest that the analysis of costs and benefits can support decision-making for both manufacturers and customers in pursuing service strategies. However, the quantitative results were not the sole outcome of the analysis, as qualitative evidence revealed that customer and manufacturer capabilities together with the operating environment have a pronounced influence in service strategy formulation.

2. Research background

2.1. Servitization as a transformation process

Manufacturing companies are increasingly integrating services with their product offerings. Yet despite the promise that services hold, the transformation from a product centred to a service centred company is not a trivial step. Servitization is a change process (Martinez et al., 2010); and such can often be disruptive, materializing through a combination of long periods of equilibrium followed by short periods of radical change (Gersick, 1991). Moreover, preparing the organization to deliver offerings that consist of a combination of products and services is a transformation process that is likely to require new mind-sets (Ulaga, 2011) and new capabilities (Brady, Davies, & Gann, 2005; Storbacka, 2011).

Looking specifically at challenges in servitization, extant literature adopts primarily the manufacturer perspective (Cakkol, 2013; Davies, 2003; Oliva & Kallenberg, 2003). Martinez et al. (2010) summarize and propose an architecture of challenges for manufacturers to undergo servitization that consists of five dimensions: the embedded product-service culture; delivery of integrated offerings; internal processes and capabilities; strategic alignment; and supplier relationships. Gebauer et al. (2005) explore why manufacturing companies that invest heavily in extending the service business do not always achieve higher returns - a phenomenon termed the “service paradox”. They employ the expectancy/valance theory of motivation by Vroom (1964) to identify cognitive phenomena that limit managerial motivation to extend the service business, and show that expected returns from services do not always justify the investment. Empirical evidence from other studies partially supports this claim. Neely (2009) observes that while the manufacturing firms that have servitized are larger than traditional manufacturing firms in terms of sales revenues, at the aggregate level they also generate lower profits and are more likely to go bankrupt. Moreover, Suarez, Cusumano, and Kahl (2013) and Fang, Palmatier, and Steenkamp (2008) uncover a convex, non-linear relationship between a product firm’s fraction of total sales coming from services and its overall operating margins.

2.2. Role of analysing costs and benefits in service strategy formulation

From the above, it becomes clear that servitization has challenges. As companies move towards higher levels of servitization, they depend on capabilities and management practices within the organization that allow them to manage and implement a PSS business model (Storbacka, 2011). PSS business models put demands on the company’s strategy definition, and invite the formulation of a service strategy that can influence the competitive strategy of the company and support business performance. Baines and Shi (2015) argue that service strategies can help providers and customers improve business efficiencies and competitiveness, focus on core competencies, and achieve cost savings and growth. However, not all physical products gain the same benefits from integration with services (Sakao, Öhrwall Rönnbäck, & Ölundh Sandström, 2013). Therefore, it is our understanding that not all systems invite the same potential for service strategies, and that even for promising systems not all strategies are likely to succeed. In light of the difficulties in implementing servitized operational strategies (Tukker, 2015; Tuli, Kohli, & Bharadwaj, 2007), it is argued that the connection between PSS offerings, service strategies, and the servitization process should be more deeply explored. In this exploration it is important to include the customer in the analysis, as any strategy for servitized products needs to focus on the delivery of value to the user (Johnson & Mena, 2008).

As shown in (Baines, Lightfoot, Peppard et al., 2009; Baines & Shi, 2015), the economic evaluation is an important part of the value proposition of a PSS. Roy and Cheruvu (2009) recognize both affordability and revenue generation opportunity as an integral part of the competitiveness of a PSS, while Storbacka (2011) argues that in formulating a strategy for product-service solutions, the financial impact needs to be significant. In the literature various approaches have been proposed for analysis of costs and benefits in PSS. Owing to the strong sustainability character of PSS (Tukker, 2015), most approaches focus on combining economic, environmental and social benefits to provide a life cycle overview of the sustainability performance of the offerings. Lindahl et al. (2014) employ Life Cycle Costing (LCC) and Life Cycle Assessment (LCA) to argue on the economic and environmental advantages of three Product Service Offerings against their equivalent product-sales business model. Peruzzini and Germani (2014) propose a structured methodology to support the preliminary design stages to estimate the global impacts of different PSS design solutions on sustainability. The authors use lifecycle approaches, namely LCA, LCC and Social LCA, to measure the impacts of each life cycle stage by means of Sustainability Indicators, which are then weighted and combined into a sustainability global assessment indicator. Abramovici, Aidi, Quezada, and Schindler (2014) present the PSS Sustainability Assessment and Monitoring (PSS SAM) framework to facilitate sustainability assessment of PSS solutions with multiple modules throughout their entire lifecycle. The proposed framework considers economic, environmental, social and PSS-specific performance through the use of

Lifecycle Indicators. It should be highlighted that Lifecycle Indicators associated to economic performance pertain to both the customer and the provider perspectives.

Lastly, an important consideration is the role of qualitative information in analysis of costs and benefits. Qualitative information concerns both data collection but also interpretation of the results and finally decision-making. Qualitative data collection is an integral part of the analysis, as qualitative methods are used for the elicitation of the necessary knowledge to formally represent the PSS (Settanni et al., 2014). Curran, Raghunathan, and Price (2004) argue that cost estimation depends on the availability of appropriate information in order to establish causal links between parameters. Towards that understanding, interviews are particularly useful, where the key points of knowledge required involve not only what is done but also how and why (Settanni et al., 2014). Moreover, qualitative information helps the analysis realize its goal, which is not just to calculate the costs and benefits, but rather to interpret them and provide a qualitative result, in form of recommendation, to the decision-making process (Boardman, Greenberg, Vining, & Weimer, 2010, p. 15). Decision-making is not exclusively based on the analysis of costs and benefits, but takes into account the political and bureaucratic state of the organization, as well as potential risks and cultural factors (Boardman et al., 2010; Sakao et al., 2013).

3. Research approach

While the extant literature on PSS and servitization agrees on the importance of financial considerations in PSS, it is not clear how the analysis of costs and benefits of PSS influences the servitization process, leading to service strategy formulation. Beuren, Gomes Ferreira, and Cauchick Miguel (2013) corroborate the existence of this gap, as they argue that the economic consequences of transforming a traditional business model to one founded on the PSS should be more deeply investigated, while Durugbo (2013) recognises the need for more research to evaluate the role of PSS such as service contracts in aligning short term decision-making to strategy formulation. This study focuses on this research gap. We acknowledge that despite their importance, economic gains only provide a partial view. The role of intangibles cannot be neglected, as they often have a greater impact on customer satisfaction than price alone (Raja, Bourne, Goffin, Çakkol, & Martinez, 2013). To summarize, any evaluation needs to balance between a quantitative assessment that provides structured results (Gambelli, Vairo, & Zanoli, 2010), and a qualitative analysis that offers insight on the complex social processes involved (Eisenhardt & Graebner, 2007) and establish the causal understanding between costs and the conditions under which they occur (Hubka & Eder, 1984, p. 59).

Against this backdrop, this study aims at studying the link between the quantitative assessment of costs and benefits of PSS and decision-making, as reflected in the formulation of service strategies for both manufacturers and their customers.

The research aim is supported by a set of intermediate research objectives:

- Evaluate costs and benefits for two PSS offerings, particularly from a life cycle perspective
- Describe how the assessment influences perceptions and supports the formulation of more holistic service strategies
- Identify critical contextual factors that can determine the success and failure of service strategy formulation

Towards those objectives, this study attempts to answer the following research question:

RQ: How does the analysis of costs and benefits of Product –Service Systems influences the formulation of service strategies in the shipping industry?

We used a multiple case study as a research method, in order to provide a base for theory building and comparisons between the cases (Eisenhardt & Graebner, 2007). Furthermore, we chose to use

LCC as described in (Hunkeler, Rebitzer, Lichtenvort, & Ciroth, 2008) as a tool to quantitatively analyse costs and benefits, together with qualitative analyses of the transformation process from both the manufacturer and customer point of view, in order to evaluate the influence of the analysis on service strategy formulation (Figure 1). We chose to use LCC instead of the more obvious choice of Cost/Benefit Analysis (CBA), as defined in (Boardman et al., 2010). This was due to the fact that CBA is mainly a policy assessment method (Boardman et al., 2010, p. 2), in contrast to LCC which is more focused on comparative assessments (Hoogmartens, Van Passel, Van Acker, & Dubois, 2014).

The research methods and tools that were used are shown in Table 1. Firstly, the study analysed related literature to identify the research gap, and proceeded to describe the industry within which the cases were operating. Extant literature in PSS and associated research streams suggest there are differences between how PSS business models are configured and conducted in different industries (Lay, Schroeter, & Biege, 2009; Storbacka, 2011). Therefore, focusing on one industry allowed us to explicitly identify the impact of industry-specific factors. The formulation of a service strategy, as shaped by the results of the qualitative and quantitative analysis, was examined from both the customer and the manufacturer perspectives. Finally, results were cross referenced with established theory on PSS and associated fields, in an effort to anchor observations and conclusions on existing theory and reflect on the implications for service strategy formulation.

For the qualitative part of the analysis, we conducted workshops on how the manufacturer could support the customer in PSS implementation and throughout the life cycle of the product. Before and after the workshop, semi-structured one hour interviews were conducted by a two-person team, in order to view the case evidence in divergent ways (Eisenhardt, 1989). In the initial interview protocol, the main area of interest was the support throughout the life cycle that manufacturers can provide to their customer. However, as the study progressed, the content and focus of the interviews

Figure 1. Research approach of the study.

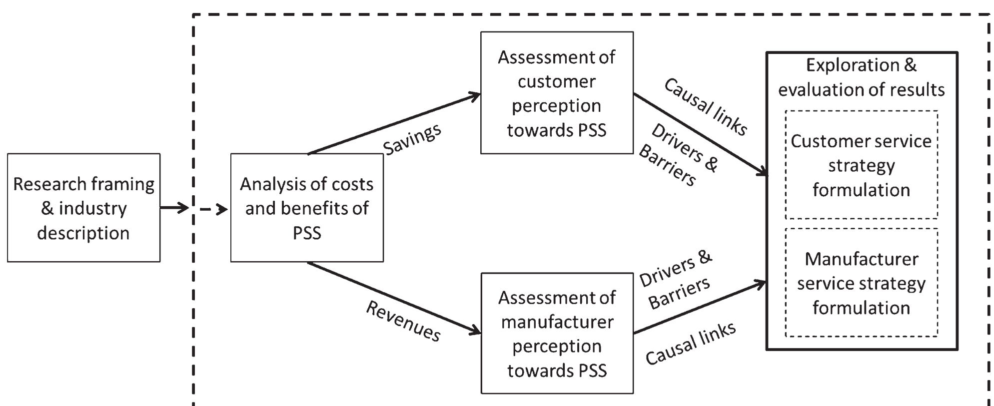


Table 1. Research methods used in the different phases of the study

Study phases	Research methods & tools
Research framing & industry description	Review of literature on shipping, servitization, PSS and associated terms; Semi structured interviews
Analysis of costs and benefits of PSS	Life Cycle Costing based on invoices, operational data and a series of interviews with participating stakeholders
Assessment of customer perception towards PSS	Workshops on life cycle support of product systems with midlevel managers; Preparatory and follow up semi-structured interviews
Assessment of manufacturer perception towards PSS	Workshops on life cycle support of product systems; Preparatory and follow up semi-structured interviews
Exploration & evaluation of results	Cross reference with extant literature, participant validation

adapted to fit each case. Appendix A shows interview questions used in the semi structured interviews. Qualitative data relied on audio transcriptions from the interview data, together with the collected material from the workshop. Participants in the qualitative study were midlevel managers, such as business developers, product managers, performance engineers and project managers. Midlevel management was identified as the appropriate target group for the study, since they are adequately close to the operation and supplier/customer base, while at the same time responsible for aligning their groups' goals with larger organizational goals (Caughron & Mumford, 2012). Finally, interviews were transcribed and coded, and data analysis was performed through systematic comparison (Strauss & Corbin, 1990, p. 95) between both the case studies and along the manufacturer/customer dichotomy.

The research involved three companies across two cases. A shipowner was the primary case company and represented the customer perspective in both case studies. Two suppliers to the shipowner, a Boiler OEM and a Paint OEM participated in one case study each. The shipowner was chosen for the collaboration due to its understanding of the concept of PSS and the fact that very open access to the necessary data was granted by the company. Both OEMs had previous experience with PSS, resulting in differentiated stances and market positioning with respect to PSS. It was assumed that the juxtaposition of the two cases would allow us to observe contrasting patterns, and allow us to compare the central constructs, relationships and logic of the focal phenomenon within each respective case (Eisenhardt & Graebner, 2007).

In regards to the analysis of costs and benefits, LCC was aligned with LCA (International Organisation for Standardization (ISO), 2006) and as a result, the analysis was conducted on the basis of a functional unit. The functional unit provided the reference to which all other data in the assessment was normalised (Weidema, Wenzel, Petersen, & Hansen, 2004), and could be translated into quantifiable reference flow(s) to which all other input and output flows quantitatively related (European Commission, 2010). System boundaries included all costs belonging to processes that were required for providing the functional unit. Within LCC, different techniques can be used for cost modelling that attempt to relate inputs to outputs (Hunkeler et al., 2008, p. 18). As the two analysed systems were different, so were the cost modelling tools that were used in each of the cases. In terms of data collection, LCC was based on data from the operation of the product and the delivery of the services. Data sources included primarily invoices, service delivery reports, and daily consumption reports.

4. Case study description

4.1. Shipping industry description

The shipping industry is concerned with the transport of cargo between seaports by ships (Lun, Lai, & Cheng, 2010, p. 1). It is one of the most internationalized industries (Lun et al., 2010, p. 1) and of paramount importance to the world economy, as it accounts for approximately 90% of the global trade (United Nations Conference on Trade & Development, 2013). Central to the industry are the ships themselves, which are long-life products with significant maintenance and energy costs (Kjær et al., 2015). Ships comprise feature multiple interconnected systems delivered by an extensive supply chain (Hameri & Paatela, 2005). These characteristics make ships a good candidate for service strategies, as the nature of servitization dictates that it mainly benefits organisations that supply and operate complex, long-life products that require through-life support (Johnson & Mena, 2008; Voss, 2005).

Shipowners are central actors in the industry, with high degree of involvement throughout the whole lifecycle of the ship, from procurement and production to operation and recycling. In this study the shipowner is responsible for the commercial and technical management of a fleet of product carriers, and operates in the tramp shipping business. Vessels in the tramp shipping business operate without a fixed schedule, carrying available cargoes between any two ports. Their schedules are dictated by economics of supply and demand (Lun et al., 2010; Stopford, 2009), resulting in an irregular and unpredictable trading pattern, which poses challenges to planning. Ship operation is also influenced by external factors such as supply/demand imbalances and trade restrictions, making the duration and volatility of market circles difficult to predict (Stopford, 2009). This has a significant cultural impact on the industry in general, as it invites a short-termed mind-set geared towards immediate problem solving.

The shipping industry provides an attractive setting for PSS, albeit fraught with challenges. Due to their long life time, complexity (Korpi & Ala-Risku, 2008; Stopford, 2009; United Nations Conference on Trade & Development, 2013). Thus, they invite a life cycle perspective as the unit of analysis. The international character of the industry means that companies in the maritime sector operate in an environment of almost perfect competition (Lun et al., 2010) where cost efficiency is a survival tactic, especially during periods of depressed markets and low profitability (Rex, Andersen, & Kristensen, 2016). At the same time though, the prevalent short term mind-set in the industry, together with practical limitations (Andersen, McAloone, & Garcia I Mateu, 2013; Stopford, 2009) can potentially hinder the formulation of PSS and their incorporation into service strategies.

The goal of the analyses was to arrive at a realistic estimate of the potential of PSS offerings in reducing life cycle costs for the product system while creating revenue streams for the manufacturer. In both cases, formal performance agreements were not currently offered or procured, but were perceived as a potential next level of servitization from both the shipowner and the OEMs. In order to elicit their benefits, a comparison was made between a baseline scenario and the performance agreement.

4.2. Case study I: Coating systems

During the operation of a vessel, a part of the hull is always immersed in the water, and therefore marine organisms accumulate on it. This undesirable accumulation of microorganisms, plants, and animals is termed marine biofouling (Yebra, Kiil, & Dam-Johansen, 2004), and results in increased fuel consumption due to generated roughness; increased corrosion of the hull and higher maintenance costs (Cao, Wang, Chen, & Chen, 2010). To prevent marine biofouling, hulls are equipped with antifouling systems. The most important part of the antifouling system is the antifouling paint that provides a low-friction, ultra-smooth surface to prevent settling, while dispersing a mix of toxic biocides to hinder fouling (Yebra et al., 2004). In many cases however, aggressive fouling might develop on the hull due to high fouling pressure especially in warm waters (Tribou & Swain, 2015), low sailing speeds (Yebra et al., 2004) and paint detachment due to mechanical damage or incorrect paint application. In these cases, in-water hull cleaning is required. During hull cleaning, the hull is cleaned by a team of divers using hull cleaning machines that brush the hull.

Under the hypothetical performance agreement, the manufacturer monitors the performance of the paint and coordinates hull cleanings, thus guaranteeing that the antifouling paint performs and the extra fuel costs do not exceed a specific threshold. The OEM producing the antifouling paint is a developer and manufacturer of marine paints, with research centres and manufacturing facilities around the world.

4.3. Case study II: Steam production on board

Steam systems are essential on-board modern vessels. Especially for tanker vessels, a constant supply of steam is required for accommodation purposes, machinery heating, fresh water production, cargo tank cleaning, and heating of cargoes to regulate their viscosity. When the vessel is stationary (e.g. during anchorage), one or two boilers are running to provide steam. During sailing, the exhaust gases from the combustion engines are circulated through the economizer, where they convert water into steam, thus eliminating the need for operating the boiler.

When the vessel is sailing slowly or at low ambient temperature, or is loaded with special cargo that must be maintained at a specific temperature (e.g. palm or vegetable oils) more steam is needed and the boiler needs to run during sailing. However, cases where a vessel reports high boiler consumption while sailing that is not due to such exceptional circumstances might signify low efficiency of the steam system. This study focuses on the boiler consumption on board one of the shipowner's vessels, hereafter referred to as Study Vessel, where a performance audit was conducted by an external expert. During the audit, a technical expert evaluates the condition of the system, identifying saving areas and provide recommendations for efficient use of the steam. Based on knowledge gained from the audit, we evaluate a hypothetical PSS, where the audit is performed by the OEM manufacturing the boilers, as they have expert knowledge on the steam system. Performance audits can be part of a formal performance agreement, under which the shipowner can ask for experts to evaluate the performance of the system at a fixed price.

The OEM manufacturing the boiler is part of a parent company, diversified in multiple industrial segments such as process industries, power plants, and sea going vessels, with competencies in key technology areas such as heat transfer, fluid handling and centrifugal separation.

5. Results

5.1. Case study I: Analysis of costs and benefits for the coating system PSS

5.1.1. Results from life cycle costing

The goal of the analysis is to compare two situations. The baseline situation describes the current situation, where vessels are cleaned two times within the five years, while the second situation corresponds to the hypothetical performance agreement, where the hull is cleaned when the fuel penalty exceeds a certain threshold. The fuel penalty is defined as the percentage increase in fuel consumption compared to the fuel consumption of a foul-free hull. The functional unit of the analysis is the five years of ship transport service, and the reference flow is the total amount of ton-kilometres during this period. Savings from performance agreement are defined as the avoided costs from the extra fuel savings, while induced costs come directly from the extra hull cleaning activity/service and indirectly from the off-hire due to vessels not being able to trade during the cleaning process.

This study focuses on a specific antifouling paint, applied on vessels of similar size and characteristics. The cost of hull cleanings was analysed directly from the relevant invoices, while the operational profiles of the vessels were extracted from daily reports. The development of fouling and its associated fuel penalty throughout the five year period was approximated by a regression model. Data collection was based on assessments of the fouling condition of the hull, collected from diver inspections before hull cleaning. Before cleaning the hull, divers assess and report the type of fouling, and the degree of coverage for the different parts of the hull. As badly fouled hulls will often attract various macrofoulers, the fuel penalty was approximated as being the sum of the contribution of each type of fouling (i.e. slime, algae and barnacles). The predictions of change in total resistance and required power for each macrofouler were based on the procedure described in (Schultz, 2007), and the estimates were verified by performance engineers from both the customer and the manufacturer.

Figure 2 shows the development of the power penalty and the fuel costs between a baseline scenario of two hull cleanings and a hypothetical performance agreement that would guarantee a power penalty below 8%. Notice that the demand for hull cleanings increases in the second half of the five year period, with shortening time intervals between hull cleanings. Figure 3 shows the difference in estimated savings between the baseline scenario and the performance agreement for the most likely scenario of average fuel prices and cyclical market conditions. Due to the high volatility in fuel prices and the multitude of assumptions involved in the calculations, a confidence interval, defined by the best, worst and most likely scenarios, is shown in Figure 3. The life cycle savings for the average scenario equalled approximately 500,000 USD during five years of transport service.

The results show a moderate case for more hull cleanings, especially towards the end of the five year period, when the active ingredients in the paint have been depleted.

Figure 2. Development of power penalty and associated extra fuel costs for the baseline scenario against the performance agreement.

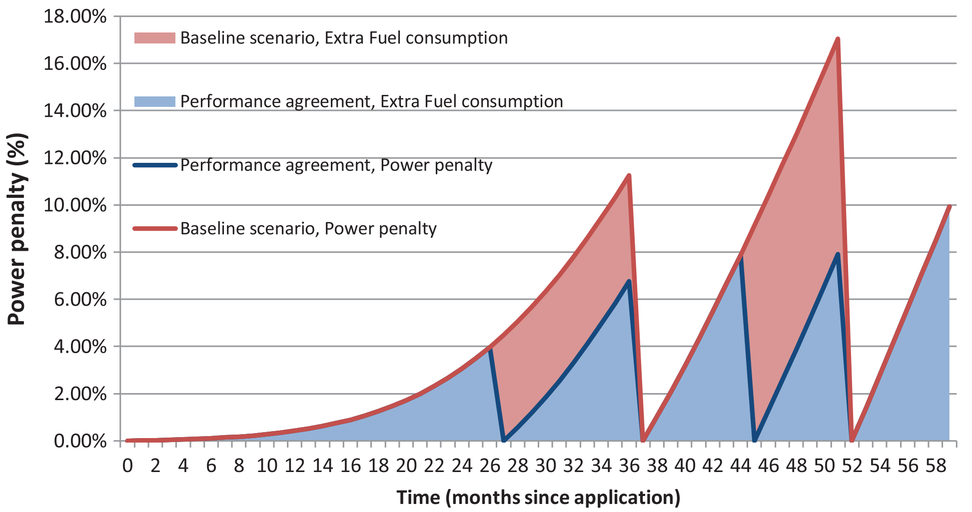
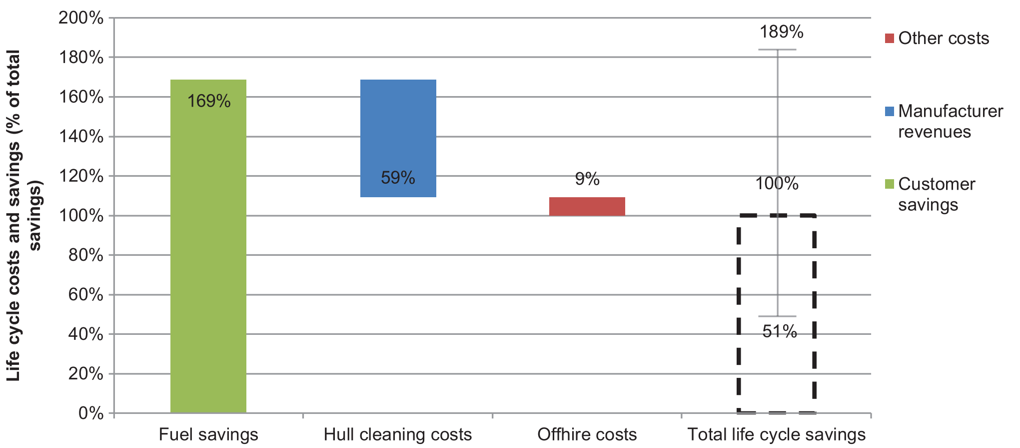


Figure 3. Summary of life cycle savings and extra costs for the performance agreements, when compared to the baseline scenario. The confidence interval in the total life cycle savings shows the results of the sensitivity analysis for the Best and Worst scenarios. For the average scenario, the Total life cycle savings amounted to a decrease of 500,000 USD per five years of transport service.



5.1.2. Reflections from the OEM side

The OEMs attitude towards the performance agreement was elicited through preparatory interviews with business developers, service and sales managers, followed by a one-day workshop, which was focused on how the OEM could support the shipowner throughout the five-year lifetime of the paint. Discussions revolved around how to choose the correct paint type for different ships, and how to ensure optimal application and support performance during operation. In terms of service offerings and besides selling different paint types, the OEM offered consultancy services during paint application in dry-dock. However, the OEM was presently not taking responsibilities for activities in the maintenance stage of the paint's life cycle.

Despite the extensive knowledge on the paint and its characteristics, the OEM did not have access to live performance data and had trouble predicting how the paint will perform throughout the life cycle due to the vessels' ever changing trading patterns. Therefore, PSS were seen as a promising way to get closer to the customer, and get a better understanding on how the paint performs. However, the OEM displayed a product-oriented attitude, as the management-driven long term goal was to develop and promote novel paint types that do not require cleaning and protect the hull from fouling even during long idle periods. The general perception was that cleaning of the paint should first of all be avoided. If cases where cleaning was absolutely necessary, it was seen as a result of either the paint not living up to its expectations or the vessel operating outside of the design specifications e.g. long idle periods in warm waters. Tanker tramp shipping was seen as a difficult and demanding customer segment, due to the irregular trading patterns and the long idle time.

Since developing, testing and launching new paint types is a long process (Willemsen & Ferrari, 1993; Yebra et al., 2004), in practice many shipowners still applied older paint types. To address this need, the OEM provided cleaning guidelines for their products, and could also suggest trustworthy cleaning companies with good track records. Therefore, while the OEM shared knowledge with the shipowner, in practice the hull cleanings were delivered by an external service network. For the OEM to support the performance agreements, it would have to either develop it or collaborate with local hull cleaning companies.

In spite of the potential revenues could be achieved from taking over the hull cleaning activities, there was no immediate plan to formalise these services into performance agreements as the OEM perceived high risks that can be hard to mitigate. Hull cleanings-especially when steel brushes need to be used- can damage the paint and diminish its antifouling capabilities. There are also other risks beside hull cleanings. Vessels often trade in ports where pollution can cause severe damage to the paint, while mechanical damage e.g. during Ship-To-Ship (STS) operations is also a tangible risk.

5.1.3. Reflections from the shipowner side

In contrast to the OEM who would recommend the newest most advanced paint types, the shipowner saw it as a risk to pursue novel technologies. While the OEM perceived fouling and the subsequent need for cleaning as sign of declining paint performance, the shipowner perceived these events as unavoidable since the vessels have irregular trading patterns, and often stay anchored in warm waters for longer periods (Pagoropoulos, Kjaer, & McAloone, 2016), so deciding when and where to hull clean was an important activity. In the words of a performance manager from the shipowner "if one of our vessels ends up staying in West Africa for more than two months, then we have to make sure that it gets cleaned before it starts sailing again". The LCC showed that this task could be optimised, both by increasing the frequency of hull cleanings, but also by improving their timing.

However, the potential fuel savings and added hull cleaning costs were not the only parameters to take into account when deciding to clean. Hull cleanings needed to fit with the operational profile of the vessels and they could potentially delay the vessel, resulting in missed trading opportunity. And due to differing environmental regulations between ports, as well as restrictions on the days that a vessel can stay in anchorage, not all ports are convenient for hull cleanings. As a result, hull cleanings could end up being postponed by a few months, resulting in extra fuel costs. Conclusively, it became clear that any potential performance agreement depended crucially on the ability to plan and align the service to the operational profile of the vessel, which necessarily would require close collaboration and a high level of synergy with the shipowner.

Lastly, the shipowner did not perceive it as likely that the OEM would be able to take over the responsibility for hull cleanings. First of all, the shipowner had vessels with paint types from different suppliers, and therefore it was not perceived as likely that a supplier would be willing to make a performance agreement for other paint types than their own. Furthermore, the demand for services occurs rather late in the life cycle of the paint. Combined with the relatively low frequency of service deliveries (4 times during a five year period), it weakens the business case, as this long-term commitment with relatively few incidents where the agreement would be used, did not seem feasible from the shipowner point of view.

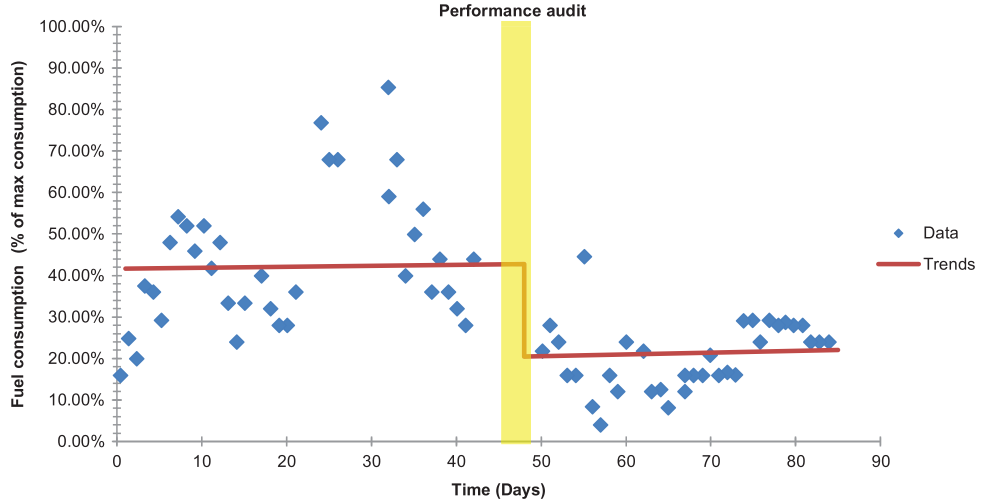
5.2. Case study II: Analysis of costs and benefits for the steam system PSS

5.2.1 Results from life cycle costing

The goal of the analysis is to evaluate the effect of performance agreements on the boiler consumption from a life cycle perspective. Focus is on comparing the situation before and after the performance audit in order to assess its impact. The functional unit of the analysis is one year of ship transport service.

Figure 4. Trend analysis, showing the savings from the intervention.

Note: The yellow bar shows the timing of the performance audit.



Savings from the performance agreement mainly come from the reduction in fuel consumption, the existence and extent of which was assessed through intervention analysis for evaluating external effects as described in (Wei, 1994, p. 212), for cases where the timing of the interventions is known. In order to assess the life cycle impact of the energy audit, a critical assumption needs to be made in regards to the time horizon of the intervention, i.e. how long do the effects last. If we perceive the audit as a knowledge-sharing activity, i.e. similar to training, literature suggests a value close to 5 years (Boardman et al., 2010, p. 210). However, in light of the frequent crew changes and irregular trading patterns, a time horizon of one year is more representative, which was confirmed through discussions with performance engineers from the shipowner's side. Analysis relied on daily consumption reports from the vessel, excluding tank cleaning events, heated cargoes, slow sailing speeds and low ambient temperature (Figure 4).

Figure 5 shows the immediate effect of the performance audit on the Study Vessel on boiler consumption at sea. Figure 6 shows the difference in life cycle costs with and without the performance agreement, in the most probable scenario of average fuel prices. Due to the high volatility in fuel prices and sensitivity of the results to the assumptions, a confidence interval is shown on the Total life cycle savings, as defined by the results of the sensitivity analysis. The life cycle savings for the average scenario equalled approximately 120,000 USD during one year of transport service.

Figure 5. Summary of life cycle savings and extra costs for performance agreements, when compared to the baseline scenario under the most probable scenario. The confidence interval in the Total life cycle savings shows the results of the sensitivity analysis for the Best and Worst scenarios. The life cycle savings for the average scenario equalled 120,000 USD during one year of transport service.

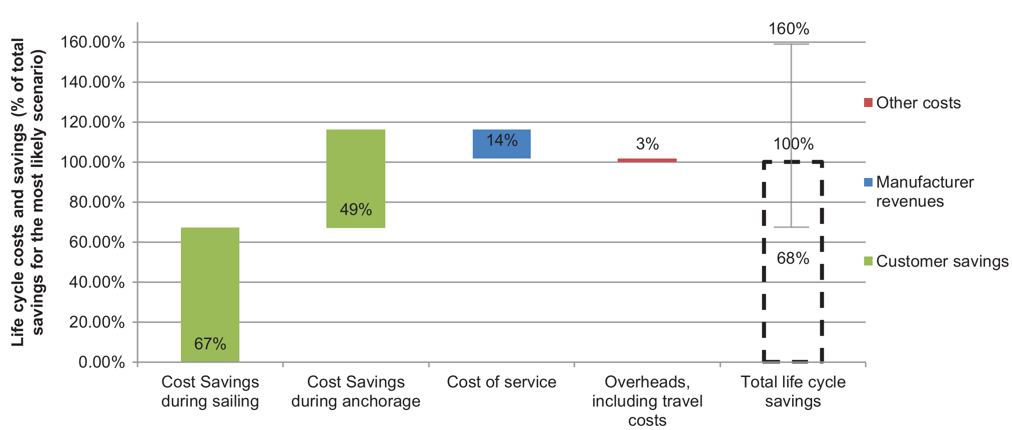
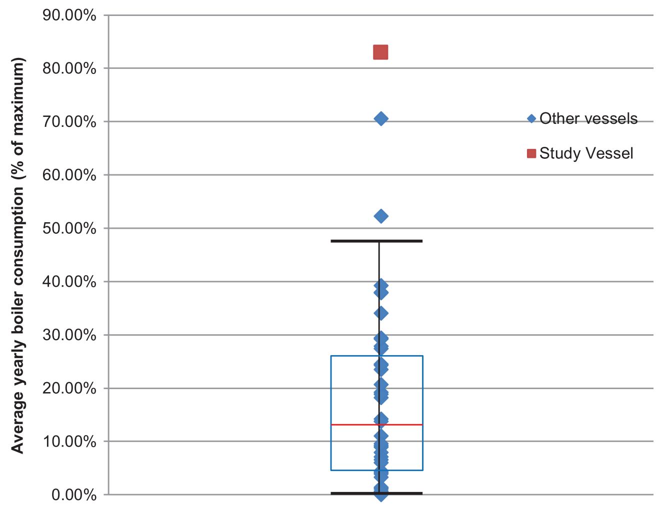


Figure 6. Boxplot showing the average boiler consumption for each vessel at sea for the fleet segment.



The results show that for vessels with high boiler consumption, performance agreements can result in substantial savings. However, taking a broader view and looking at the fleet-wide performance reveals a smaller overall savings potential. Figure 6 shows that, on average, most of the vessels report very low boiler consumption and that the Study Vessel is an outlier to the fleet.

5.2.2. Reflections from the OEM side

The OEMs perception towards performance agreements as a service strategy was evaluated through a workshop on how the OEM could support the shipowner throughout the operation of the steam system, especially through the delivery of advanced services. Moreover, the potential for and attitude towards performance agreements were discussed. Performance agreements were a formalised strategic goal within the OEM, and such agreements were already established for land-based segments, as they were seen as playing an essential role in a strategic move for the company from selling products to selling knowledge. Competitors are also moving in the same direction.

The OEM saw itself as a highly reputable company that did not compete in price, but in quality and value delivered. Furthermore, the OEM already had the global service network necessary but would need to formalise the already established mechanisms for service delivery. It was a clear goal of the company to start defining service packages for customers to procure. Towards that goal, they recognized the need to get closer to their customers' core business and become more of a strategic partner.

The results of the LCC confirmed the OEM's perception that energy savings and revenue opportunities would be possible by delivering advanced services. A fact being that such an audit would require extensive knowledge on the whole steam system and not only boilers, since it is rarely the boilers but often the system around them that has the biggest potential for optimization.

From the OEM side, towards the customer base, an important consideration was to perform the customer segmentation, and match performance agreements to the different needs and profiles of the customer base. In the words of an account manager "some of our customers just want us to go on board for a few hours, others really want us to get involved. We have to be flexible."

5.2.3. Reflections from the shipowner side

From the shipowner side, the results were seen as promising. Suggestions and recommendation from the findings of the performance audit were shared across the vessels, and led to fleet-wide improvements. Thus, the service itself was only a part of the overall solution - the largest benefit came from the shipowner's ability to reflect and implement changes across the fleet. Learnings from

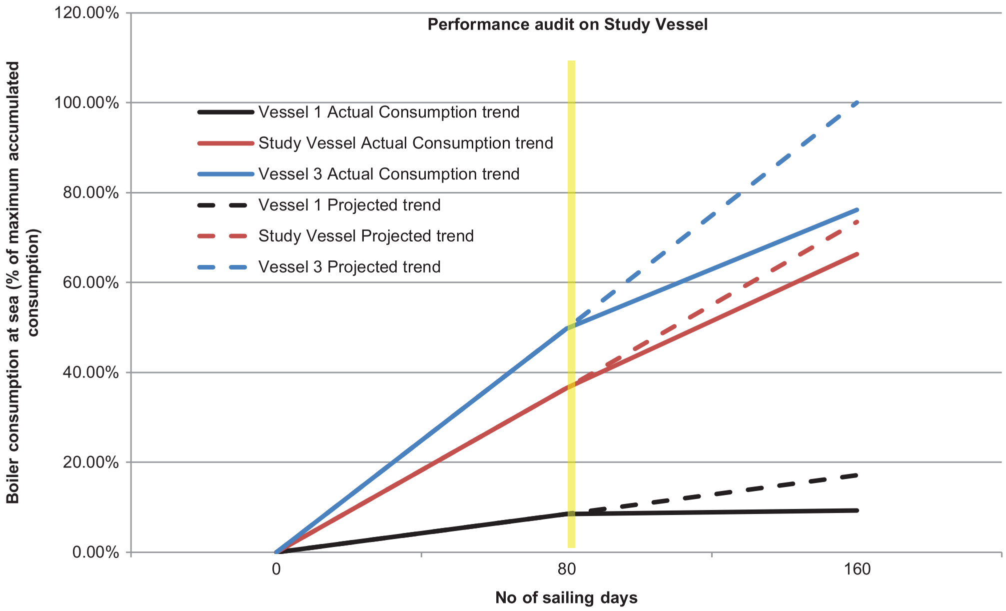


Figure 7. Spill-over effects from knowledge dissemination within the shipowner. Fuel savings during the evaluated period are equal to the difference between the actual and the projected consumption. Notice that while the audit was conducted only on the Study Vessel, Vessel 3 showed the biggest improvement in the group and Vessel 1 achieved the desired goal of zero boiler consumption at sea.

Note: The yellow bar shows the timing of the performance audit.

the performance audit were disseminated across vessels of the same design, resulting in significant "spill-over" effects, as shown in Figure 7. Thus, the shipowner naturally questioned the actual need for buying PSS that would cover the whole fleet. Instead, focus was on creating functions and processes towards the internal market that can capture "the low hanging fruit" in terms of savings, and ensure knowledge reuse and dissemination throughout the organization.

Notice that the shipowner's reflections were not targeted as an attempt to discredit the impact of performance audits on energy efficiency. The results showed that expert help can be necessary. However, energy efficiency is not seen as a direct causal effect of a specific product-service combination, but rather as an outcome of multiple interconnected factors. Some of these factors (e.g. spare parts quality) have deep roots within the technical characteristics of the system, while other factors are linked to behavioural (e.g. maintenance standards by the crew) or operational (e.g. heating requirements) characteristics. A series of interventions, similar to the ones that would be included in a performance agreement, essentially influenced these. However, it would be very difficult to estimate a priori magnitude of the effects and guarantee a performance target. As also discussed in (Armstrong, 2013), savings require a continuous focus on performance, which necessitates that there a constant follow up on the operation of the steam system- a task that would be very difficult to carry out for an external stakeholder with limited access to the shipowner's operation.

6. Discussion

The discussion section attempts to summarize and reflect on the findings of the study. At first, the findings of the quantitative analysis are compared to those of the qualitative analysis. Moreover, given the embedded character of the multiple case study (Yin, 2003), the manufacturer perspective is juxtaposed against the customer perspective, particularly elucidating the influence of contextual factors for both perspectives. Lastly, findings are compared to existing literature on PSS.

Table 2 summarizes the findings of the four-way case study.

In both case studies, the analysis of costs and benefits showed a decrease in life cycle costs for the customer and a possible revenue opportunity for the manufacturers. Substantial savings on the order of 100,000 USD per year per ship can be attained by improving the way in which ships are being managed through a PSS implementation.

Table 2. Key constructs from analysis of costs and benefits, and their influence on service strategy formulation

Key observed constructs from analysis	Associated research phase	Influence on customer service strategy formulation	Influence on manufacturer service strategy formulation
Revealed economic potential, verified by the existence of savings and revenues	Analysis of costs and benefits	Has a positive effect, helps the customer formulate a strategy in order to capture savings through PSS adoption	Has a positive effect, helps the manufacturer formulate a strategy in order to capture revenues through PSS implementation
Lack of fundamental demand for PSS	Analysis of costs and benefits	Questioned the need for formalized agreements	Questioned the economic viability of the PSS
Results depend on customers' ability to support and implement PSS offering	Analysis of costs and benefits/Assessment of customer perception towards PSS	Focus area in service strategy implementation	Need to identify customer requirements, strengths and weaknesses in service strategy implementation
Results depend on manufacturers' ability to support and implement the PSS offering	Analysis of costs and benefits/Assessment of manufacturer perception towards PSS	Service strategy implementation may be undermined by distrust in the capabilities of the manufacturer to successfully deliver PSS	Need to expand capabilities to service and support systems that are outside of their own product portfolio
The operating environment of the shipping industry	Research framing/Assessment of manufacturer and customer perceptions towards PSS	Has a strong influence on PSS delivery	Has a strong influence on PSS implementation

Their benefits however are shown to depend on technical parameters i.e. the frequency of the intervention and the prior condition of the system. For any service strategy to be successful, it must be optimized in regards to such parameters. Increasing the frequency at which the service is delivered is likely to diminish the life cycle savings, and might run the risk of not breaking-even. Furthermore, services are not always needed, as in many cases the systems under study are performing adequately without the need for external interventions. This shows that, for the systems that were studied, there are issues that can often lead to lack of fundamental demand for PSS, which can complicate the formulation and subsequent implementation of a service strategy. These two limitations highlight the fact that formulating a service strategy requires careful consideration, accurate prediction and in depth understanding of the life cycle of the physical product.

LCC provided a strong foundation for quantifying costs and benefits stemming from PSS. However, the quantitative results were not the only influencing parameters, as qualitative parameters had a strong influence on service strategy formulation for both customers and manufacturers.

When, in light of the results of the analysis, we investigated the manufacturer perception towards service strategies, we saw that it depends on both the manufacturers' and the customers' ability to support the PSS offering. In both cases, manufacturers need to expand their capabilities to service and support systems that are outside of their own product portfolio. The boiler OEM for example recognized the need to acquire an understanding of the whole steam system, while the paint OEM would need to develop data analytic capabilities to monitor and assess the life cycle performance of the paint. Furthermore, the customers' capabilities proved also to have an influence on the manufacturers' service strategy. Specifying and implementing a service strategy needs to consider the customer requirements, strengths and weaknesses. The tanker tramp shipping segment was seen as particularly challenging by the paint OEM, impeding formulation of formalized agreements. Moreover, customer segmentation was seen as an important step by the boiler OEM in addressing the varying needs and requirements of the customer base.

The cross-case comparison between the two manufacturing companies revealed a series of common drivers and barriers which, by enlarge, have already been discussed in extant literature on servitization. The most important barriers were the lack of supporting organizational arrangements that could support service strategy formulation, fuelled by a dominant product culture and imperfect knowledge on the way their products were being used (Gebauer et al., 2005; Martinez et al., 2010). At the same time though, both OEMs recognized the need for service offerings, which allow them to be closer to their customers, and therefore saw the need for service offerings that can sustain these relationships (Raja et al., 2013).

Moreover, and although the analysis of costs and benefits highlighted a business opportunity for both manufacturers, their perceptions and capabilities towards consolidating services and formulating service strategies differed substantially. The boiler OEM had a global service network that could be geared towards supporting service strategies. That was not the case for the paint OEM, which would have to either build an independent network, or work on developing relationships with local service suppliers. Moreover, for the boiler OEM, service strategies were supported by a strong focus on creating strategic internal alignment within the organization. Formulating a service strategy was seen as both a competitive advantage—especially while competition is moving ahead with servitization initiatives—and an intentional move from selling products to selling knowledge. In the case of the paint OEM, service strategies were not equally endorsed by the management as services entail risks that can be hard to mitigate.

The customer perception revealed a more relational view of service strategies (Tuli et al., 2007). Savings were not seen as a solitary outcome of the activities of the manufacturer, but depend crucially on customer's ability to identify and adapt to external constraints. An important consideration was the ability to learn and institutionalize new capabilities, as a result of projects being delivered within the context of the service strategy. Savings did not strictly depend on the products or the services that support them, but were a result of various technical, operational and behavioural factors. Influencing those factors requires continuous focus, and a service strategy needs to build learning loops that refine the focus, content, and quality of the service being delivered. Therefore, a prerequisite from the customer side for the successful adoption of service strategies is the existence of internal processes and capabilities that enable quick and efficient planning, seizing opportunities, following up on performance indicators, and disseminating knowledge and results throughout the organization. At the same time, service strategy implementation requires a certain level of trust in the capabilities of the manufacturer. Reflecting on both case studies, conflicts of interest—particularly on products and systems produced by a third OEM- and lack of synergies with the manufacturer can undermine the endeavor.

The customer's ability to benefit from PSS implementation is the main takeaway of this study, and has important managerial implications for service strategy formulation. Service strategies should not be seen as one-off solutions, but rather as embedded processes that deliver value (Johnson & Mena, 2008), create flexible organizations that focus on their core competencies (Oliva & Kallenberg, 2003), provide increased insight into the optimal use of the products (Alonso-Rasgado & Thompson, 2006), and support the whole customer-supplier process from requirement definition and integration to deployment and post deployment (Tuli et al., 2007). When formulating a service strategy, either in the manufacturer or the customer organization, the goal is not simply to make things "better" or "cheaper", but more importantly to make the strategy fit in the socio technical environment that customers are experiencing. Therefore, it is important that manufacturers secure that their solutions are integrated into the customer's process in order to support value creation during usage of the solution (Storbacka, 2011).

To the best of our knowledge, there are no studies that suggest that all customers can equally benefit from a service strategy that is likely to be relationship intensive (Raja et al., 2013), disrupt traditional ownership models (Tukker, 2015), and distribute risks and responsibilities across the supplier network (Johnson & Mena, 2008). On the contrary, literature acknowledges a series of prerequisite capabilities such as the existence of contracting skills, management information, process compliance, relational skills and flexible budgeting systems (Baines & Shi, 2015; Windler, Jüttner, Michel, Maklan, & Macdonald, 2016). This study extends this list of prerequisites and recognizes the need for integration within the customer organization, the ability to reuse and disseminate knowledge, and the existence of analytical skills that can demonstrate the benefits from service strategy adoption.

Lastly, formulation of service strategies is affected by the operating environment that is only captured in the qualitative part of the analysis of costs and benefits. Despite the appropriateness of the ship for PSS, the cyclicality in the shipping industry invites a short-term outlook that makes long term agreements difficult. Moreover, commercial considerations result in irregular trading patterns, further eroding the ability of the customer organization to "reach out" to the vessel. The manufacturer is also affected by an operational environment that poses practical limitations on the type of services that can be part of a service strategy.

7. Conclusions

In this article we aimed to answer the following question:

> RQ: How does the analysis of costs and benefits of Product-Service Systems influences the formulation of service strategies in the shipping industry?

The case studies showed that the analysis of costs and benefits of PSS can support decision-making for both suppliers and customers in pursuing service strategies. In this sense, a LCC approach can determine the financial benefits of PSS and on that basis formulate a service strategy that will allow suppliers and customers to co-create value.

Taking a life cycle perspective provides an overview of the potential benefits, both in terms of the magnitude of savings and revenues that can be achieved, but also in terms of the frequency and actual need for the PSS. For both case studies, LCC revealed that although the PSS resulted in a decrease in life cycle costs and a possible revenue opportunity, there is also a lack of fundamental demand that can complicate the formulation of service strategies. However, the case studies also showed that the quantitative assessment was not the only decisive parameter. Taking a step away from the quantitative results to the qualitative evidence and in particular the contextual factors that can enable those cost savings and revenues, the case studies highlighted the importance of both customer and the manufacturer capabilities to deliver and implement a PSS.

These qualitative conclusions would not have been possible based on the quantitative analysis of costs and benefits alone. Therefore we argue that to examine service strategy formulation, the analysis of costs and benefits needs to consider both quantitative and qualitative costs and benefits. Future work could include a deeper study of the customer perspective, especially in regards to drivers and factors that can help customers adopt and capture the benefits from service strategies.

This study suffers from a series of constraints that limit its generalizability. Data collection was largely focused on the first stages of the transformation process, and we were thus unable to follow the complete process of service strategy implementation. Future work could include a longitudinal study going beyond formulation and into service strategy implementation. Another limitation relates to the difficulty in generalizing the findings due to the attention to one industry, whose idiosyncrasies and characteristics appear to have a pronounced influence on the formulation of service strategies. Further work could look deeper into the implementation of service strategies in other industries and explore the Business-to-Consumer (B2C) markets.

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Appendix A

Interview question plan in semi structured interviews

(1) What are the main barriers and opportunities for performance agreements?
(2) How your worldwide network organized, in order to deliver the agreement?
(3) In your opinion, what are the potential benefits of the performance agreement and how would you or your customers rank them?
    - e.g. risk mitigation/perceived security, saved costs, stable costs, predictable uptime (guaranteed uptime)
(4) How do you engage the different departments in the customer organizations? (e.g. technical management, procurement, crew on board)
(5) How do you utilize the information from monitoring systems and performance agreements to optimize the agreement with the ship owner?
(6) In light of increasing consolidation in the maritime sector, how do you see performance agreements in the future?
(7) You claim a short payback time. How do you calculate this and can you actually provide customers with an estimate beforehand?
(8) How do you build the business case for performance agreements (how to you calculate savings vs. service costs)?
(9) How do you validate the savings you achieve for your customers?
(10) What is being defined in a performance agreement?
(11) From the your newsletter and performance agreements brochure, one notices absence of boiler agreements and limited presence of “deep sea shipowners”. Why do you think that is happening?
(12) In the newsletters, focus was always on tangible savings and payback times. What is the average improvement that you see/estimate? Could you share success stories?
(13) Within performance agreements, is the customer obliged to buy spare parts?
(14) How do performance agreements influence the behavior and attitude of crew on board?
(15) In order to execute a performance audit, do you have people traveling to the vessel, or do you use local representatives?
(16) How important are performance monitoring systems to support the service performance agreement?